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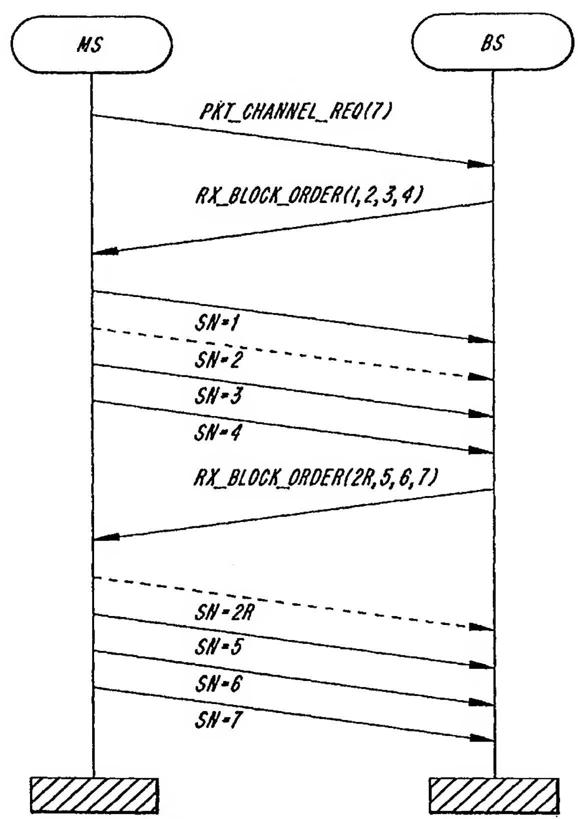
(57) Abstract

A radiocommunication system supports forward error correction (FEC)/automatic retransmission (ARQ) schemes for handling erroneously received data blocks. Transmission of sequence numbers associated with each data block are transmitted independently of the data blocks themselves, which results in, among other benefits, reduced latency and improved memory utilization. By decoupling transmission of the payload data from the block and sub–block identity, a more robust variable redundancy scheme is created. For example, a group of block sequence numbers can be transmitted together as a bit map, whereby individual sequence numbers need not be completely specified. Instead, a starting sequence number can be completely specified, with additional sequence numbers then being represented by subsequent offsets or increments from the starting sequence number.



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GROUP ADDRESSING IN A PACKET COMMUNICATION SYSTEM

BACKGROUND

The present invention generally relates to error handling in the field of communication systems and, more particularly, to error handling using automatic retransmission requests (ARQ) and variable redundancy in digital communication systems.

The growth of commercial communication systems and, in particular, the explosive growth of cellular radiotelephone systems, have compelled system designers to search for ways to increase system capacity without reducing communication quality beyond consumer tolerance thresholds. One technique to achieve these objectives involved changing from systems wherein analog modulation was used to impress data onto a carrier wave, to systems wherein digital modulation was used to impress the data on carrier waves.

In wireless digital communication systems, standardized air interfaces specify most of the system parameters, including modulation type, burst format, communication protocol, etc. For example, the European Telecommunication Standard Institute (ETSI) has specified a Global System for Mobile Communications (GSM) standard that uses time division multiple access (TDMA) to communicate control, voice and data information over radio frequency (RF) physical channels or links using a Gaussian Minimum Shift Keying (GMSK) modulation scheme at a symbol rate of 271 ksps. In the U.S., the Telecommunication Industry Association (TIA) has published a number of Interim Standards, such as IS-54 and IS-136, that define various versions of digital advanced mobile phone service (D-AMPS), a TDMA system that uses a differential quadrature phase shift keying (DQPSK) modulation scheme for communicating data over RF links.

TDMA systems subdivide the available frequency into one or more RF channels. The RF channels are further divided into a number of physical channels corresponding to timeslots in TDMA frames. Logical channels are formed of one or several physical

channels where modulation and coding is specified. In these systems, the mobile stations communicate with a plurality of scattered base stations by transmitting and receiving bursts of digital information over uplink and downlink RF channels.

Digital communication systems employ various techniques to handle erroneously received information. Generally speaking, these techniques include those which aid a receiver to correct the erroneously received information, e.g., forward error correction (FEC) techniques, and those which enable the erroneously received information to be retransmitted to the receiver, e.g., automatic retransmission request (ARQ) techniques. FEC techniques include, for example, convolutional or block coding of the data prior to modulation. FEC coding involves representing a certain number of data bits using a certain (greater) number of code bits, thereby adding redundancy which permits correction of certain errors. Thus, it is common to refer to convolutional codes by their code rates, e.g., 1/2 and 1/3, wherein the lower code rates provide greater error protection but lower user bit rates for a given channel bit rate.

ARQ techniques involve analyzing received blocks of data for errors and requesting retransmission of blocks which contain errors. Consider, for example, the block mapping example illustrated in Figure 1 for a radiocommunication system operating in accordance with the Generalized Packet Radio Service (GPRS) optimization which has been proposed as a packet data service for GSM. Therein, a logical link control (LLC) frame containing a frame header (FH), a payload of information and a frame check sequence (FCS) is mapped into a plurality of radio link control (RLC) blocks, each of which include a block header (BH), information field, and block check sequence (BCS), which can be used by a receiver to check for errors in the information field. The RLC blocks are further mapped into physical layer bursts, i.e., the radio signals which have been GMSK modulated onto the carrier wave for transmission. In this example, the information contained in each RLC block can be interleaved over four bursts (timeslots) for transmission.

When processed by a receiver, e.g., a receiver in a mobile radio telephone, each RLC block can, after demodulation and FEC decoding, be evaluated for errors using the block check sequence and well known cyclic redundancy check techniques. If there are

errors after FEC decoding, then a request is sent back to the transmitting entity, e.g., a base station in a radiocommunication system, denoting the block to be resent.

The GPRS optimization provides four FEC coding schemes (three convolutional codes of different rate and one uncoded mode). After one of the four coding schemes is selected for a current LLC frame, segmentation of this frame to RLC blocks is performed. If an RLC block is found to be erroneous at the receiver and needs to be retransmitted, the originally selected FEC coding scheme is used for retransmission, i.e., this system employes fixed redundancy for retransmission purposes. The retransmitted block may be combined with the earlier transmitted version in a process commonly referred to as soft combining in an attempt to successfully decode the transmitted data.

Another proposed scheme, commonly referred to as variable redundancy, provides for additional redundant bits to be transmitted if the originally transmitted block cannot be decoded. This scheme is conceptually illustrated in Figure 2. Therein, three decoding attempts are made by the receiver. First, the receiver attempts to decode the originally received data block (with or without redundancy). Upon failure, the receiver then receives additional redundant bits R1, which it uses in conjunction with the originally transmitted data block to attempt decoding. As a third step, the receiver obtains another block of redundant information R2, which it uses in conjunction with the originally received data block and the block of redundant bits R1 to attempt decoding for a third time. This process can be repeated until successful decoding is achieved.

One problem with the technique illustrated in Figure 2 is the large memory requirement associated with storing the data block (and possibly additional blocks of redundant bits) until a successful decode occurs, which storage is needed since the subsequently transmitted redundancy blocks (e.g., R1 and R2) are not independently decodable. The storage requirements are multiplied by the fact that the receiver typically stores a multi-bit soft value associated with each received bit, the soft values indicating a confidence level associated with the decoding of the received bit. This problem can be partially solved by employing the technique described in the article entitled "Complementary Punctured Convolutional (CPC) Codes and their Applications"

to Samir Kallel, published in IEEE Transactions on Communications, Vol. 43, No. 6, pp. 2005-2009 in June 1995. Therein, the author describes an error correction technique wherein each retransmitted block is itself independently decodable so that when memory space is unavailable previously transmitted blocks can be discarded.

When either soft combining or variable redundancy are employed, however, an explicit numbering sequence of the transmitted blocks is required in order to distinguish between the different information blocks and/or blocks of redundant bits, so that proper processing of the blocks can be performed by the receiver. This is typically performed by appending a sequence number to the transmitted block, which the receiver then uses to match the received block with other, previously received blocks associated with the same data for combining/decoding.

Sending the sequence number for a block with the data that it represents is also problematic. For example, if the sequence number is received erroneously, then the receiver may not be able to determine how to use the received information for decoding or soft combining purposes. Some solutions have been proposed to deal with the problem of preserving the sequence number. For example, it has been proposed that the sequence number be more highly protected, e.g., using a lower code rate, than the payload data to which it is appended. In this way, the receiver is more likely to receive a decodable sequence number and more likely to know, for example, how to properly match up the received block with others that it has previously received.

However, transmitting the sequence number together with the payload data creates other inefficiencies in a radio environment which are not addressed by known designs. When the sequence number and the payload data are transmitted at the same time on the same frequency, it is highly probable that both will either be correctly received or incorrectly received. In variable redundancy schemes, it is desirable to correctly decode the block identity, e.g., the sequence number, associated with an incorrectly decoded payload data portion in order to properly decode it by associating it with other sub-blocks.

Accordingly, it would be desirable to provide new techniques for improving ARQ schemes which reduce overhead signalling, improve the efficiency of memory

utilization and identify sub-blocks in a manner which will permit more efficient variable redundancy processing.

SUMMARY

These and other drawbacks and limitations of conventional methods and systems for communicating information are overcome according to the present invention, wherein the receiver controls the block order sent by the transmitter so that the transmitter need not include a sequence number with each transmitted block. In this way, the receiver will implicitly know which stored block or blocks (if any) should be processed in conjunction with a recently received block, regardless of whether the recently received block was received with one or more errors.

According to exemplary embodiments of the present invention, the receiver can send a receive block order message to the transmitter identifying a sequence order for transmission. When the receiver erroneously receives a block of information such that a retransmission is necessary, it indicates which block should be retransmitted and the position of the retransmitted block within the next set of blocks to be transmitted. In this way, the receiver knows precisely which block is being received without a sequence order number being included with each transmitted data block.

According to other exemplary embodiments of the present invention. The receiver can inform the transmitter of the block sequence on a block-by-block basis. For example, the receiver can itself transmit blocks of data to the transmitter which include a transmission control field. The transmission control field specifies the block number of the next block that the transmitter should send to the receiver. If a block needs to be retransmitted (or if additional redundant bits associated with an earlier transmitted block are to be provided), then the value in the transmission control field will reflect the earlier transmitted block's sequence number.

In packet data systems, channels can be shared among, for example, plural mobile stations. If, for example, one mobile station is only receiving data on a downlink portion of a channel pair and another mobile station is only transmitting data on an uplink portion of a channel pair, the former mobile station will receive

transmission control field values which are directed to the latter mobile station. However, the latter mobile station will be identified in the downlink transmissions by an uplink state flag so that the former mobile station will ignore the system's instructions regarding which block to transmit next.

According to another exemplary embodiment of the present invention, the transmitter can send a message to the receiver that informs the receiver of the subsequent block transmitting order. The transmitter can then send the blocks of data in this predetermined order, again without appending sequence numbers thereto.

By decoupling transmission of the payload data from the block and sub-block identity, a more robust variable redundancy scheme is created. For example, a group of block sequence numbers can be transmitted together as a bit map, whereby individual sequence numbers need not be completely specified. Instead, a starting sequence number can be completely specified, with additional sequence numbers then being represented by subsequent offsets or increments from the starting sequence number.

BRIEF DESCRIPTION OF THE DRAWINGS

These and other objects, features and advantages of the present invention will become more apparent upon reading from the following detailed description, taken in conjunction with the accompanying drawings, wherein:

FIG. 1 depicts information mapping in a conventional system operating in accordance with GSM;

FIG. 2 illustrates a conventional variable redundancy technique;

FIG. 3(a) is a block diagram of a GSM communication system which advantageously uses the present invention;

FIG. 3(b) is a block diagram used to describe an exemplary GPRS optimization for the GSM system of FIG. 3(a);

FIG. 4 illustrates receiver controlled ARQ according to an exemplary embodiment of the present invention;

FIG. 5 shows a conventional GPRS format for a downlink data block;

FIG. 6 shows a format for a downlink data block according to an exemplary embodiment of the present invention;

FIG. 7(a) illustrates the coding relationship between sub-blocks according to one exemplary FEC/ARQ scheme;

FIG. 7(b) depicts mapping of radio blocks to TDMA frames in an exemplary GPRS system showing the location of stealing bits;

FIG. 8 shows a sequence of uplink and downlink transmissions according to an exemplary embodiment of the present invention;

FIG. 9 depicts another format for a downlink data block according to another exemplary embodiment of the present invention; and

FIG. 10 depicts signalling according to an exemplary network controlled ARQ embodiment of the present invention.

DETAILED DESCRIPTION

The following exemplary embodiments are provided in the context of TDMA radiocommunication systems. However, those skilled in the art will appreciate that this access methodology is merely used for the purposes of illustration and that the present invention is readily applicable to all types of access methodologies including frequency division multiple access (FDMA), TDMA, code division multiple access (CDMA) and hybrids thereof.

Moreover, operation in accordance with GSM communication systems is described in European Telecommunication Standard Institute (ETSI) documents ETS 300 573, ETS 300 574 and ETS 300 578, which are hereby incorporated by reference. Therefore, the operation of the GSM system in conjunction with the proposed GPRS optimization for packet data (hereafter referred to simply as "GPRS") is only described herein to the extent necessary for understanding the present invention. Although, the present invention is described in terms of exemplary embodiments in an enhanced GPRS system, those skilled in the art will appreciate that the present invention could be used in

a wide variety of other digital communication systems, such as those based on wideband CDMA or wireless ATM, etc.

Referring to FIG. 3(a), a communication system 10 according to an exemplary GSM embodiment of the present invention is depicted. The system 10 is designed as a hierarchical network with multiple levels for managing calls. Using a set of uplink and downlink frequencies, mobile stations 12 operating within the system 10 participate in calls using time slots allocated to them on these frequencies. At an upper hierarchical level, a group of Mobile Switching Centers (MSCs) 14 are responsible for the routing of calls from an originator to a destination. In particular, these entities are responsible for setup, control and termination of calls. One of the MSCs 14, known as the gateway MSC, handles communication with a Public Switched Telephone Network (PSTN) 18, or other public and private networks.

At a lower hierarchical level, each of the MSCs 14 are connected to a group of base station controllers (BSCs) 16. Under the GSM standard, the BSC 16 communicates with a MSC 14 under a standard interface known as the A-interface, which is based on the Mobile Application Part of CCITT Signaling System No. 7.

At a still lower hierarchical level, each of the BSCs 16 controls a group of base transceiver stations (BTSs) 20. Each BTS 20 includes a number of TRXs (not shown) that use the uplink and downlink RF channels to serve a particular common geographical area, such as one or more communication cells 21. The BTSs 20 primarily provide the RF links for the transmission and reception of data bursts to and from the mobile stations 12 within their designated cell. When used to convey packet data, these channels are frequently referred to as packet data channels (PDCHs). In an exemplary embodiment, a number of BTSs 20 are incorporated into a radio base station (RBS) 22. The RBS 22 may be, for example, configured according to a family of RBS-2000 products, which products are offered by Telefonaktiebolaget L M Ericsson, the assignee of the present invention. For more details regarding exemplary mobile station 12 and RBS 22 implementations, the interested reader is referred to U.S. Patent Application Serial No. 08/921,319, entitled "A Link Adaptation Method For Links using

Modulation Schemes That Have Different Symbol Rates", to Magnus Frodigh et al., the disclosure of which is expressly incorporated here by reference.

An advantage of introducing a packet data protocol in cellular systems is the ability to support high data rate transmissions and at the same time achieve a flexibility and efficient utilization of the radio frequency bandwidth over the radio interface. The concept of GPRS is designed for so-called "multislot operations" where a single user is allowed to occupy more than one transmission resource simultaneously.

An overview of the GPRS network architecture is illustrated in Figure 3(b). Since GPRS is an optimization of GSM, many of the network nodes/entities are similar to those described above with respect to Figure 3(a). Information packets from external networks will enter the GPRS network at a GGSN (Gateway GPRS Service Node) 100. The packet is then routed from the GGSN via a backbone network, 120, to a SGSN (Serving GPRS Support Node) 140, that is serving the area in which the addressed GPRS mobile resides. From the SGSN 140 the packets are routed to the correct BSS (Base Station System) 160, in a dedicated GPRS transmission. The BSS includes a plurality of base transceiver stations (BTS), only one of which, BTS 180, is shown and a base station controller (BSC) 200. The interface between the BTSs and the BSCs are referred to as the A-bis interface. The BSC is a GSM specific denotation and for other exemplary systems the term Radio Network Control (RNC) is used for a node having similar functionality as that of a BSC. Packets are then transmitted by the BTS 180 over the air interface to a remote unit 210 using a selected information transmission rate.

A GPRS register will hold all GPRS subscription data. The GPRS register may, or may not, be integrated with the HLR (Home Location Register) 220 of the GSM system. Subscriber data may be interchanged between the SGSN and the MSC/VLR 240 to ensure service interaction, such as restricted roaming. The access network interface between the BSC 200 and MSC/VLR 240 is a standard interface known as the A-interface, which is based on the Mobile Application Part of CCITT Signaling System No. 7. The MSC/VLR 240 also provides access to the land-line system via PSTN 260.

As mentioned above, retransmission techniques can be provided in system 10 so that a receiving entity (RBS 180 or MS 210) can request retransmission of (or redundant bits associated with) an RLC block from a transmitting entity (MS 210 or RBS 180). According to exemplary embodiments of the present invention, the block sequence number is decoupled from the transmission of the data blocks themselves, so that the receiver is implicitly aware of the sequence number of a received block, without needing that information to be transmitted along with the payload data.

Consider the example illustrated in Figure 4, which is referred to herein as a receiver controlled ARQ scheme. In this example, the transmitter (e.g., a mobile) sends a channel request message to a receiver (e.g., a base station) indicating that it will be transmitting seven blocks of information. Responsive to this request, the receiver sends a message to the transmitter indicating the order in which it would like to receive the blocks. This may be some subset (in this example, four) of the total number of blocks to be transmitted. The message can, for example, take the form of a bitmap wherein a starting sequence number is completely specified, e.g., to six or seven bits, while subsequent sequence numbers in the same order are specified as increments thereto. The transmitter then transmits the blocks in the indicated order, without appending the sequence number. The receiver processes each received block, according to any of the aforedescribed techniques, e.g., the variable redundancy technique, using its knowledge of the sequence order that it defined in the RX_BLOCK_ORDER message. As part of this processing, the receiver determines whether any of the received blocks have uncorrectable errors, such that additional redundant bits need to be retransmitted in order to perform a second decoding pass for that block.

After the first four blocks have been transmitted and received, the receiver then transmits a second RX_BLOCK_ORDER message indicating the desired order for the remaining blocks to be transmitted. As shown in Figure 4, in this second message, the receiver requests that a first set of redundancy bits for one of the originally received blocks be transmitted, i.e., redundant bits R1 for block #2. In this particular example, the receiver specifies that R1 for block #2 should be transmitted first, followed by blocks #5, 6 and 7. Upon receipt of the redundancy bits R1 for block #2, the receiver

can readily associate this information with the previously received (and stored) block #2 and perform a second decoding attempt as indicated, for example, in Figure 2, since the receiver recognizes the redundancy bits by virtue of its earlier request message to the transmitter. In this way, the receiver can properly operate on received blocks without having to properly decode a sequence number transmitted with each block. To further illustrate how this technique may be employed consider the following more detailed exemplary embodiments.

First, an exemplary embodiment will be described wherein the base station is the packet data receiver and the mobile station is the packet data transmitter. Thus, the base station will inform the mobile station on the downlink of the order of the packets to be transmitted on the uplink. For this exemplary GPRS embodiment, this can be accomplished by extending the GPRS MAC header, whose traditional format is illustrated in Figure 5, to include the sequence number of the block to be transmitted by the mobile station within the next block period on the uplink. In the traditional format illustrated in Figure 5, the block format includes a MAC header comprising the uplink state flag (USF), the supplementary/polling bit (S/P), the relative reserved block period (RRBP) and the payload type (PT), an RLC Data block including a header (RLCH) and payload data, and a block check sequence (BCS).

Blocks to be transmitted can be numbered with sequence numbers as in the current GPRS system. However, according to this exemplary embodiment of the present invention, the network can include a sequence number of a block to be transmitted by the mobile station in the uplink with each downlink block transmitted to that mobile station or group of mobile stations sharing the same packet data channel (PDCH). Although multiple mobile stations may be using the same PDCH, only the mobile station having the USF reservation specified in the MAC header (i.e, having its identity in the USF field) for a particular block will use the sequence number transmitted by the network to determine its next block transmission, i.e., the next new block or a retransmission/redundancy bits associated with a previous block. The sequence number can, for example, be transmitted in a newly defined field in the MAC header referred to herein as the transmission control flag (TCF), which field is illustrated in Figure 6.

Moreover, the same sequence number can be repeated in downlink transmissions any number of times to retransmit (soft combining) or transmit different redundancy units (variable redundancy) associated with a particular block until successful decoding occurs.

According to this exemplary embodiment of the present invention, the retransmissions/transmitting of redundancy units for an erroneously received block can be requested during the next block period following the erroneous reception using the TCF field in the downlink block. This will substantially reduce the requirements for the receiver's memory, since a minimum number of blocks will be outstanding (i.e., awaiting successful decoding) at a given time. Analogously, this technique will aid in performing transmissions within a comparatively smaller transmission window size than conventional retransmission techniques, which in turn means that a smaller sequence number can be used, e.g., seven bits or fewer. By making the sequence number smaller, bandwidth associated with overhead signalling is reduced both for the block to be transmitted on the uplink (if the sequence number is transmitted therein) and for the TCF field in the downlink.

Under certain circumstances, e.g., error correction schemes involving retransmission using increased coding and soft combining, it is also useful to identify which version (referred to as "sub-block number") of a particular block is being processed. This concept is illustrated in Figure 7(a), wherein four sub-blocks associated with the same radio block are illustrated. Therein, sub-block 1 represents the original, uncoded data. Sub-block 2 represents the data plus one block of redundancy bit, which is the equivalent of ½ coding rate. Similarly, sub-blocks 3 and 4 represent the data plus two and three blocks of redundancy bits, resulting in 1/3 and 1/4 coding rates, respectively. By allowing the receiver to request transmission of specific sub-blocks, it is possible for the network to request, for example, retransmission of the sub-block received with the lowest carrier-to-interference ratio (C/I).

In order to indicate a sub-block number according to the present invention, exemplary embodiments of the present invention use the so-called "stealing" bits. Originally, the phrase "stealing bits" arose from the fact that, in GSM speech and circuit

switched service. Therefore, when some urgent signalling is to be sent to the receiver, the sender replaces, for example, a complete speech frame with the signalling message. Therefore, the speech frame is said to be "stolen" by the signalling message and this is indicated through the stealing flags or bits.

The location of the stealing bits in the physical layer is described in Figure 7(b). These stealing bits are used for a different purpose in GPRS systems, although they are still referred to using this name. As shown, in GPRS systems a radio block having 456 bits is transmitted in four TDMA frame periods with one burst in each frame. A burst occupies one slot in the TDMA frame. Different FEC coding rates can be obtained with different puncturing schemes. For example, four coding rates are specified in GPRS, i.e., 1/2, 2/3, 3/4 and 1. The coding rate used for a particular radio block is indicated using the stealing bits. Since a radio block is transmitted on four bursts with two stealing bits per burst, eight bits are available to indicate the coding rate.

Exemplary embodiments of the present invention use the stealing bits for yet a different purpose. Since none of these coding schemes are required when using hybrid ARQ or soft combining, these stealing bits can be used according to the present invention to indicate a sub-block number associated with a particular transmission/reception. In particular, the codewords shown below in Table 1, which can be backwards compatible, eight bit codes with a Hamming distance of 5, can thus be arbitrarily assigned to unique sub-block numbers.

Sub-block number	**code word**
1	1111 1111
2	1100 1000
3	0010 0001
4	0001 0110

Table 1

Alternatively, it may be necessary to explicitly indicate sub-block numbers, in which case the TCF field may be extended, e.g., by two bits, to indicate both block and sub-block numbers.

An example of receiver controlled ARQ in accordance with this exemplary embodiment is illustrated in Figure 8. Therein, the upper level of rectangles represent uplink packets transmitted by the mobile station to the network having sequence numbers SN = k, l, wherein k= block # and l= sub-block#, although these numbers are, as described above, not explicitly transmitted by the mobile station. The lower level of rectangles represent downlink packets transmitted by the network to the mobile station (or group of mobile stations sharing the channel) indicating a sequence number for a next packet to be transmitted as well as a particular USF value. In this example, two users, i and j, share a same PDCH for transmission to the network. Note that in this example, some unspecified default value (D) can be transmitted as the TCF value when the network is requesting the next new block (i.e., previously untransmitted block). Of course, those skilled in the art will appreciate that a default need not be used and the network could instead transmit an actual sequence number in all cases. When the CRC fails for a particular block received by the network, then the network indicates that the block should be retransmitted and/or that redundancy bits be transmitted therefor. This is exemplified in Figure 8, by the second uplink block (SN = 8,1) which is indicated as having a failed CRC. Note that the next downlink block includes a TCF value associated with the erroneously received block # 8, whereupon the mobile transmits block # 8, sub-block # 2 in the next time slot.

If USF indications are required, then it may be necessary for the network to provide continuous downlink transmissions. Otherwise, e.g., if only one user is allocated to a particular PDCH, then the network may not transmit a downlink packet in each available timeslot. In such cases, the mobile station may equate a transmission absence with a request for a next packet in sequence, i.e., as if the default TCF value had been transmitted.

The foregoing exemplary embodiment focuses on the base station acting as the receiver and the mobile station acting as a transmitter, in which situation the receiver controls the order of blocks to be transmitted. The present invention is also applicable to the reverse situation, an exemplary embodiment for which will now be described. As on the uplink, multiple temporary block flows (TBFs) can be multiplexed on single downlink PDCH, however this adds to the complexity for supporting variable redundancy since the intended mobile station recipient must also be explicitly identified in the downlink.

As mentioned earlier, different mobile stations transmitting on a single PDCH are distinguished by the use of the USF field. Specifically, the network indicates from which mobile station (USF) it is requesting a certain block (TCF) to be transmitted on the uplink. According to the present invention, this same technique can also be used for the downlink to indicate to which mobile station a particular downlink data block is directed. Thus, as shown in Figure 9, a downlink state field (DSF) can be added to the MAC header identifying the mobile station in much the same way as the USF, i.e., using the same identification numbering scheme, same coding, etc. Accordingly, both the USF and DSF may be transmitted on the downlink. The USF refers to the mobile station which will transmit on the uplink in the next block period, while the DSF indicates the mobile station within a group sharing the same downlink PDCH. Of course, the USF and DSF may have different values, e.g., when the payload data transmitted on the downlink is intended for a different mobile station than the request for transmission indicated by the USF.

In a manner analogous to that described with respect to the exemplary embodiment of Figure 4, the order of blocks to be transmitted from the network can be relayed to the mobile station by the network using a TX BLOCK ORDER message. This message could be sent as part of a packet downlink assignment message to the mobile station or in response to an Acknowledged/Not Acknowledged (ACK/NACK) message from the mobile station. An example of this signalling is illustrated in Figure 10. Therein, the network assigns the mobile station a downlink PDCH and indicates that it will first transmit blocks #1-4. After transmitting these four blocks, the mobile

acknowledges receipt of blocks #1, 3 and 4, but not block #2. The network then informs the mobile station that it will retransmit block #2 (and/or additional redundancy bits) followed by block #5. The network follows this signalling with a message indicating that blocks #6 and 7 will be transmitted, thereafter transmitting these same blocks.

In addition to being part of the assignment message or following an ACK/NACK message from the mobile, the TX BLOCK ORDER message can also be sent whenever it is deemed necessary by the network. Thus, the mobile station will follow the sequence numbers specified according to the most recently received TX BLOCK ORDER message from the network.

The format of the TX BLOCK ORDER message may, as will be appreciated by those skilled in the art, vary depending upon design considerations. However, a format similar to that conventionally used for the ACK/NACK message may be used wherein a bitmap representing the sequence order of blocks is transmitted. For example, if the stealing bits are used to represent the sub-block numbers, then the bitmap may take the format illustrated below as Table 2, wherein the starting sequence number is one and each bit represents whether a particular block is to be transmitted. Thus, Table 2 depicts a TX BLOCK ORDER message wherein blocks #1-4 are to be transmitted, i.e., the first four bits in the bitmap are 1's followed by 0's.

	S	S	N	=	1		
1	1	1	1	0	0	0	0
0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0

Table 2

If sub-block numbers need to be explicitly defined in the TX BLOCK ORDER message, e.g., because the stealing bits cannot be used to indicate sub-block numbers, other formats for the TX BLOCK ORDER message may be used. For example, Table 3 depicts a bitmap format wherein the network indicates to a mobile station that it will transmit block #2b followed by block #5a, i.e., the second transmission associated with block #2 and the first transmission associated with block #5.

	S	S	N	=	2		
1	0	0	0	0	0	0	1
0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0

Table 3

In this example, the starting sequence number is two and each two consecutive bits in the bitmap refer to a block and sub-block number combination as further described in Table 4.

00	No transmission
01	sub-block a
10	sub-block b
11	sub-block c

Table 4

Thus, in the example of Table 3, the first two bits '10' indicate that block #2 is being transmitted as version 2b, the following two '00' bit fields indicate that blocks #3 and #4 are not being transmitted and the subsequent '01' field indicates that block #5 is being transmitted as version 5a, i.e., the first transmission thereof.

In summary, the foregoing exemplary embodiments of the present invention provide alternative mechanisms for block addressing which can be applied, for example, in packet data transmissions in radiocommunication systems. The present invention provides, among other things, for de-coupling of the transmission of payload data and its associated sequence number. For example, prior to a block of data being transmitted by a transmitter on the uplink, a receiver can request, on the downlink, that the transmitter transmit that particular block. In this way, the transmitter need not transmit a sequence number with the block of data to be transmitted. This de-coupling effect can result in the sequence number and the data block associated therewith being transmitted at

transmit that particular block. In this way, the transmitter need not transmit a sequence number with the block of data to be transmitted. This de-coupling effect can result in the sequence number and the data block associated therewith being transmitted at different times and/or on different frequencies if, for example, the downlink and uplink channels reside on different frequencies when operated in FDD (Frequency Division Duplex) mode and on different times when operated in TDD (Time Division Duplex) mode. By decoupling transmission of the payload data from the block and sub-block identity, a more robust variable redundancy scheme is created. For example, a group of block sequence numbers can be transmitted together as a bit map, whereby individual sequence numbers need not be completely specified. Instead, a starting sequence number can be completely specified, with additional sequence numbers then being represented by subsequent offsets or increments from the starting sequence number.

Moreover, the present invention also reduces memory requirements since the TCF for uplink data transfer also serves as the ACK/NACK message. Thus, a sequence number will be transmitted within the TCF as soon as there is a missing block and the redundancy/retransmission will be performed within the next block period. Additionally, less overhead is used since an ACK/NACK message will be used less frequently.

Although the invention has been described in detail with reference only to a few exemplary embodiments, those skilled in the art will appreciate that various modifications can be made without departing from the invention. The block order messages or transmission control field described above can include more information than simply a sequence number. For example, if more than one block/sub-block are transmitted together within a block period, e.g., by interleaving the blocks/sub-blocks within the block period (e.g., four TDMA bursts as shown in Figure 7(b)), then the block order messages or transmission control field can include information associated with how to perform extraction of the various blocks/sub-blocks as well as their identification numbers. Accordingly, the invention is defined only by the following claims which are intended to embrace all equivalents thereof.

WHAT IS CLAIMED IS:

1. A radiocommunication system comprising:

a mobile station for transmitting a plurality of blocks of data on an uplink channel, said mobile station including a first processor;

a base station for receiving said plurality of blocks of data on said uplink channel, said base station including a second processor;

wherein said base station determines a desired sequence order for said plurality of blocks to be transmitted by said mobile station;

wherein said base station transmits information to said mobile station indicating a sequence order in which said mobile station is to transmit said plurality of blocks of information;

wherein said first processor processes said information and controls transmission of said plurality of blocks in accordance therewith; and

wherein said second processor receives said plurality of blocks in said desired order and processes each block based on its sequence number.

2. The radiocommunication system of claim 1, wherein said base station transmits, as said information, a block order message indicating an order for transmission of multiple data blocks.

3. The radiocommunication system of claim 1, wherein said base station transmits, as said information, a transmission control field in a downlink block on a downlink channel, wherein said transmission control field indicates a sequence number of a next of said plurality of blocks to be transmitted by said mobile station.

4. The radiocommunication system of claim 3, wherein said transmission control field contains a default value when said base station is not requesting retransmission.

5. The radiocommunication system of claim 3, wherein said uplink channel and said downlink channel are transmitted using a different transmitting parameter including at least one of: a different frequency, a different timeslot and a different spreading code.

6. The radiocommunication system of claim 1, wherein said mobile station transmits said plurality of blocks in said sequence order without appending sequence numbers thereto.

7. The radiocommunication system of claim 1, wherein sub-block numbers are indicated by a mapping of stealing bits.

8. The radiocommunication system of claim 3, wherein said transmission control field also indicates a sub-block identity.

9. The radiocommunication system of claim 2, wherein said block order message is a bit map having a starting sequence number followed by at least one increment thereto.

10. A method for transmitting a plurality of blocks of information from a transmitter to a receiver in a radiocommunication system comprising the steps of:

requesting, by said receiver, a particular sequence in which said plurality of blocks are to be transmitted by transmitting a message indicating said sequence to said transmitter; and

transmitting, by said transmitter, said plurality of blocks in said sequence to said receiver.

11. The method of claim 10, wherein said step of transmitting further comprises the step of:

transmitting said plurality of blocks without appending a sequence number thereto.

12. The method of claim 10, wherein said receiver is a base station in said radiocommunication network and said transmitter is a mobile station.

13. The method of claim 10, wherein said plurality of blocks include a retransmission/redundancy block of information associated with another block of information that was previously transmitted to said receiver.

14. A method for communicating a plurality of blocks of information from a transmitter to a receiver in a radiocommunication system comprising the steps of:

transmitting, by said transmitter, a message indicating a sequence order in which said plurality of blocks are to be transmitted;

transmitting, by said transmitter, said plurality of blocks in said sequence to said receiver; and

processing, by said receiver, each of said plurality of blocks using a sequence number obtained from said message indicating said sequence order.

15. The method of claim 14, wherein said step of processing further comprises the steps of:

recognizing, from said message, that a received block includes information associated with an earlier received block;

retrieving said earlier received block from memory; and

attempting to jointly decode said received block and said earlier received block.

16. The method of claim 14, wherein said second step of transmitting further comprises the step of:

transmitting said plurality of blocks without appending a sequence number thereto.

17. The method of claim 14, wherein said receiver is a mobile station in said radiocommunication network and said transmitter is a base station.

18. The method of claim 14, wherein said plurality of blocks include a retransmission/redundancy block of information associated with another block of information that was previously transmitted to said receiver.

19. The method of claim 10, wherein said request is formatted as a bit map having a starting sequence number followed by at least one increment thereto.

20. The method of claim 14, wherein said request is formatted as a bit map having a starting sequence number followed by at least one increment thereto.

21. The system of claim 3, wherein said transmission control field also provides information regarding interleaving of said plurality of blocks.

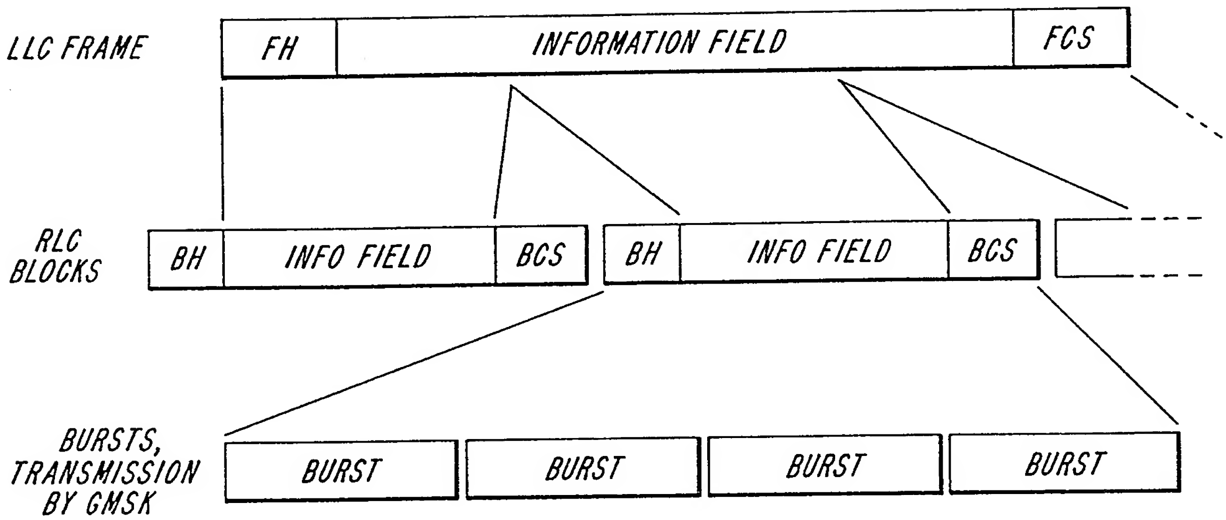


Fig. 1
(PRIOR ART)

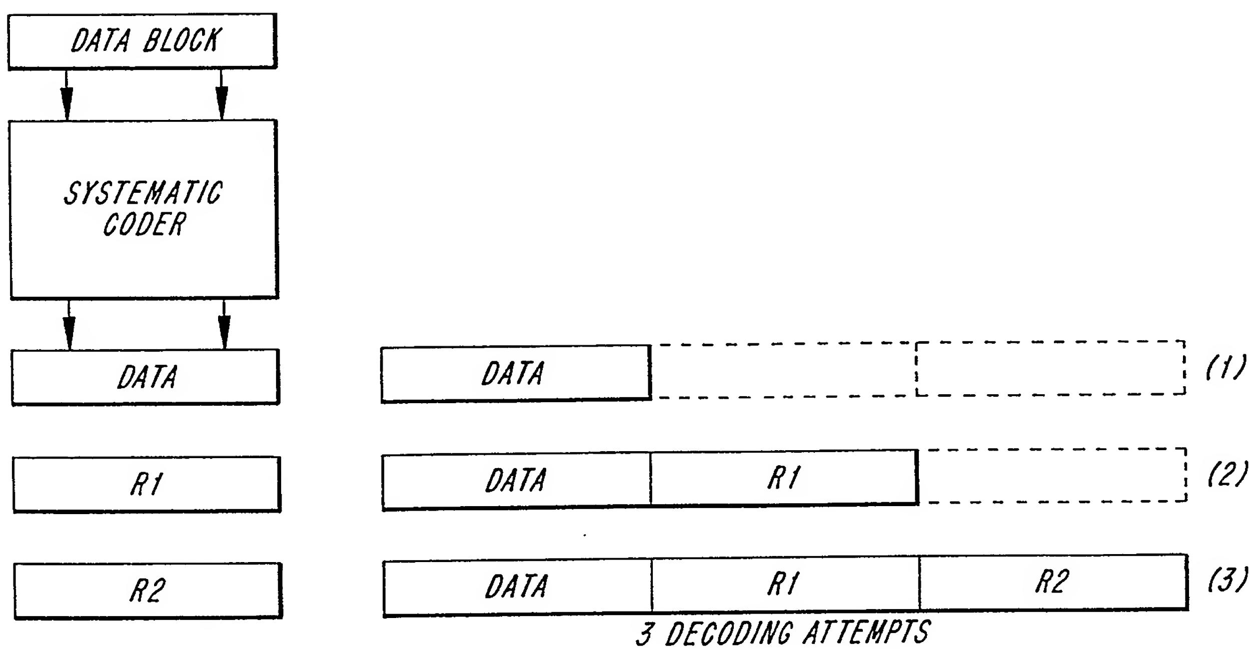


Fig. 2
(PRIOR ART)

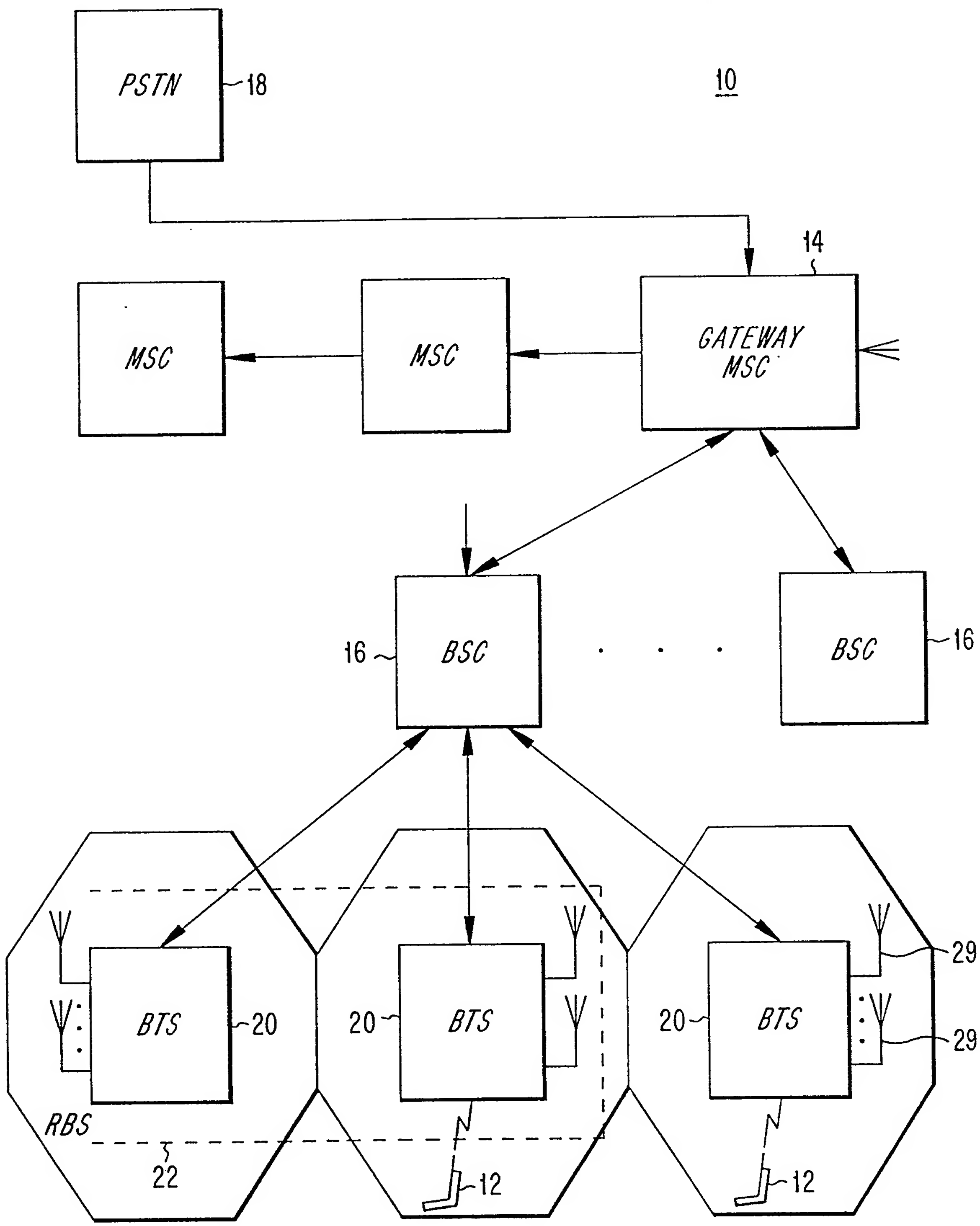


Fig. 3(a)
(PRIOR ART)

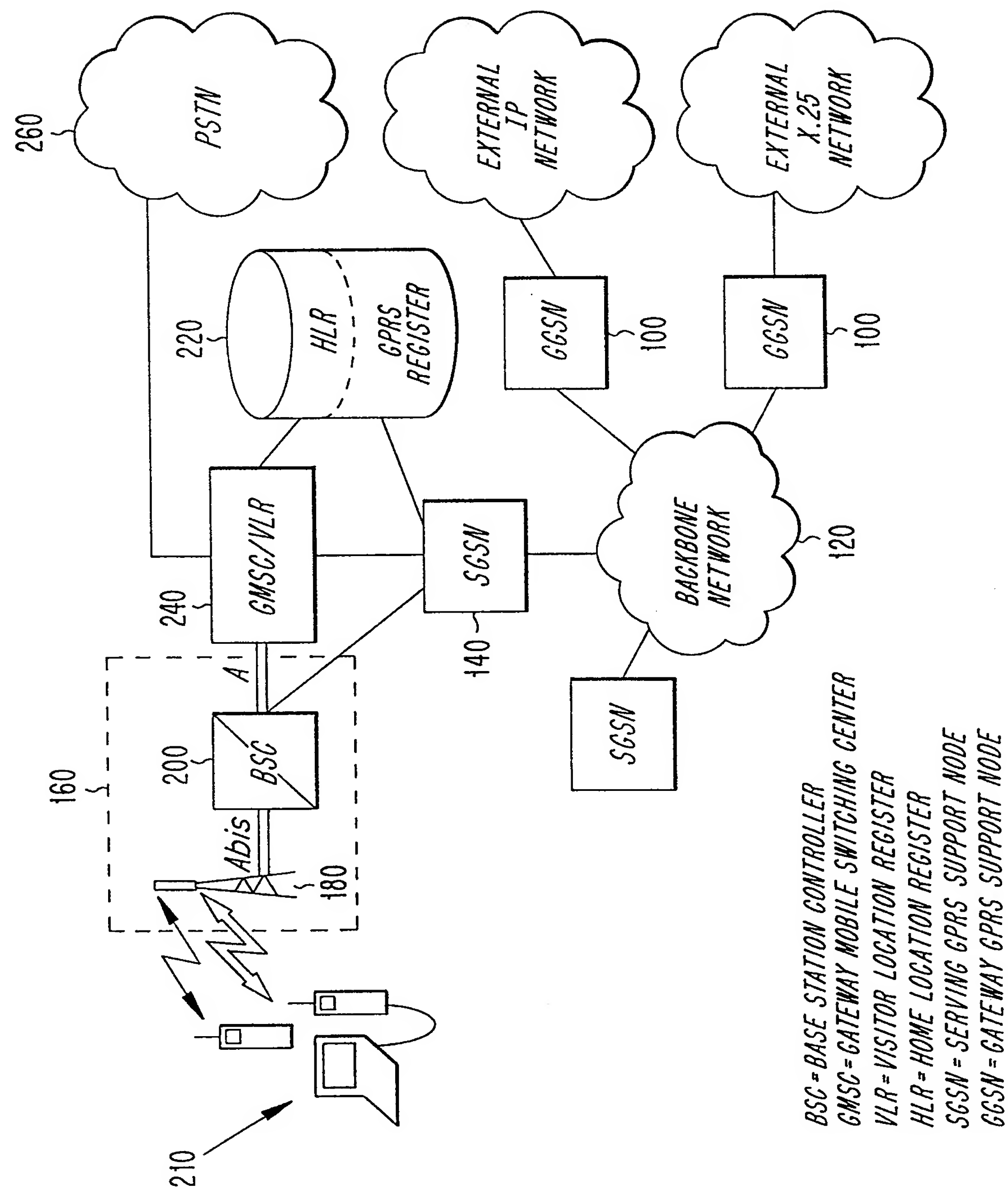

260
PSTN
EXTERNAL IP NETWORK
EXTERNAL X.25 NETWORK
220
HLR
GPRS REGISTER
GGSN
100
GGSN
100
240
GMSC/VLR
SGSN
140
BACKBONE NETWORK
120
SGSN
160
200
BSC
A
Abis
180
210
BSC = BASE STATION CONTROLLER
GMSC = GATEWAY MOBILE SWITCHING CENTER
VLR = VISITOR LOCATION REGISTER
HLR = HOME LOCATION REGISTER
SGSN = SERVING GPRS SUPPORT NODE
GGSN = GATEWAY GPRS SUPPORT NODE

Fig. 3(b)

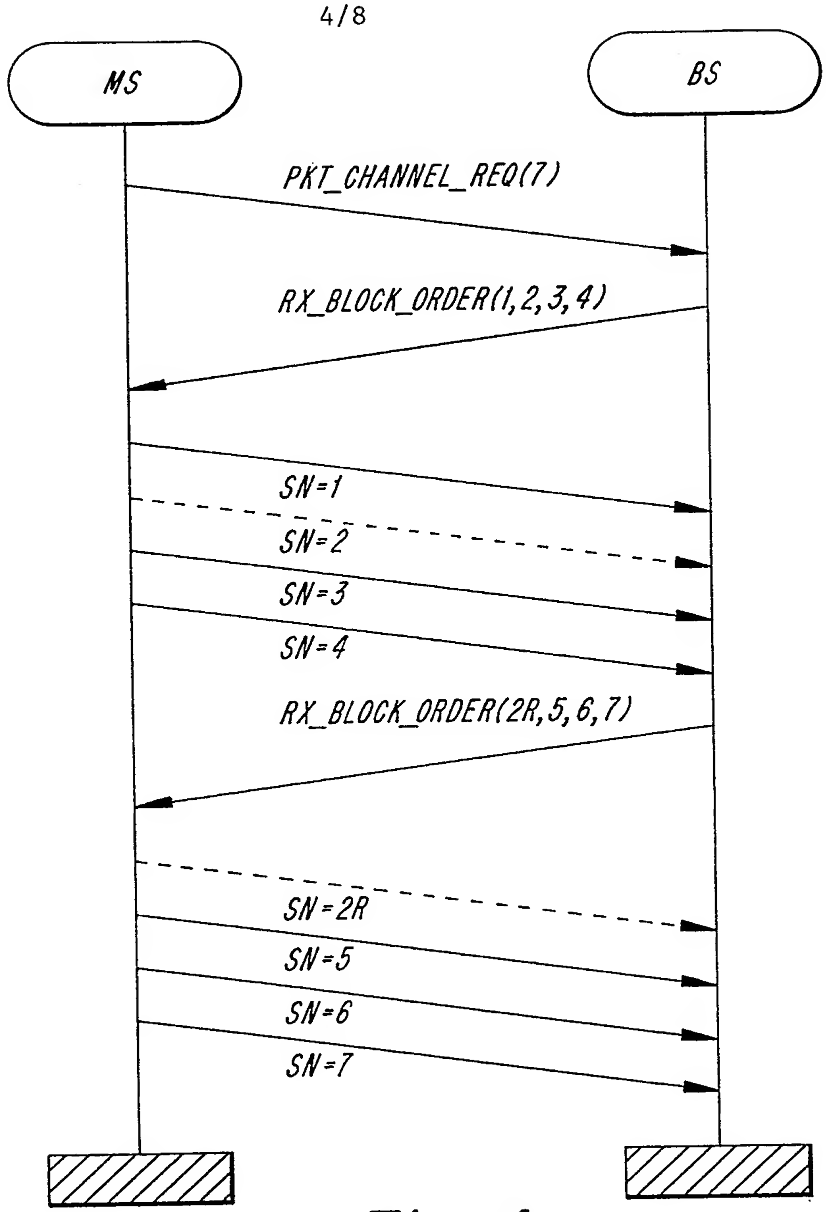


Fig. 4

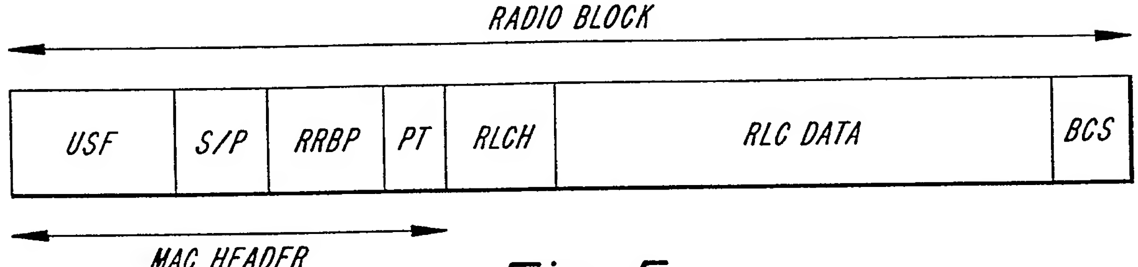


Fig. 5
(PRIOR ART)

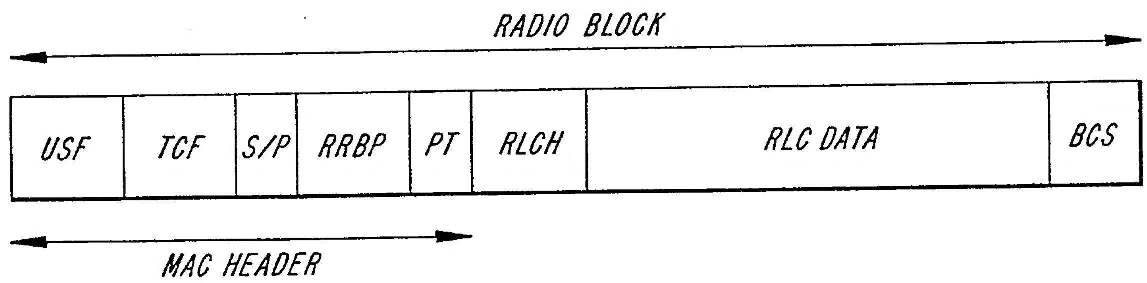

RADIO BLOCK
USF
TCF
S/P
RRBP
PT
RLCH
RLC DATA
BCS
MAC HEADER

Fig. 6

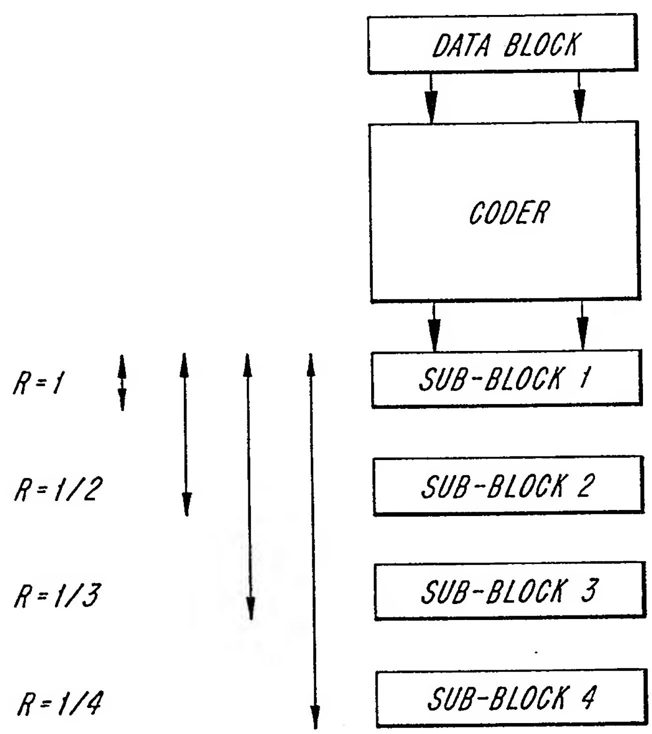

DATA BLOCK
CODER
R = 1
R = 1/2
R = 1/3
R = 1/4
SUB-BLOCK 1
SUB-BLOCK 2
SUB-BLOCK 3
SUB-BLOCK 4

Fig. 7(a)

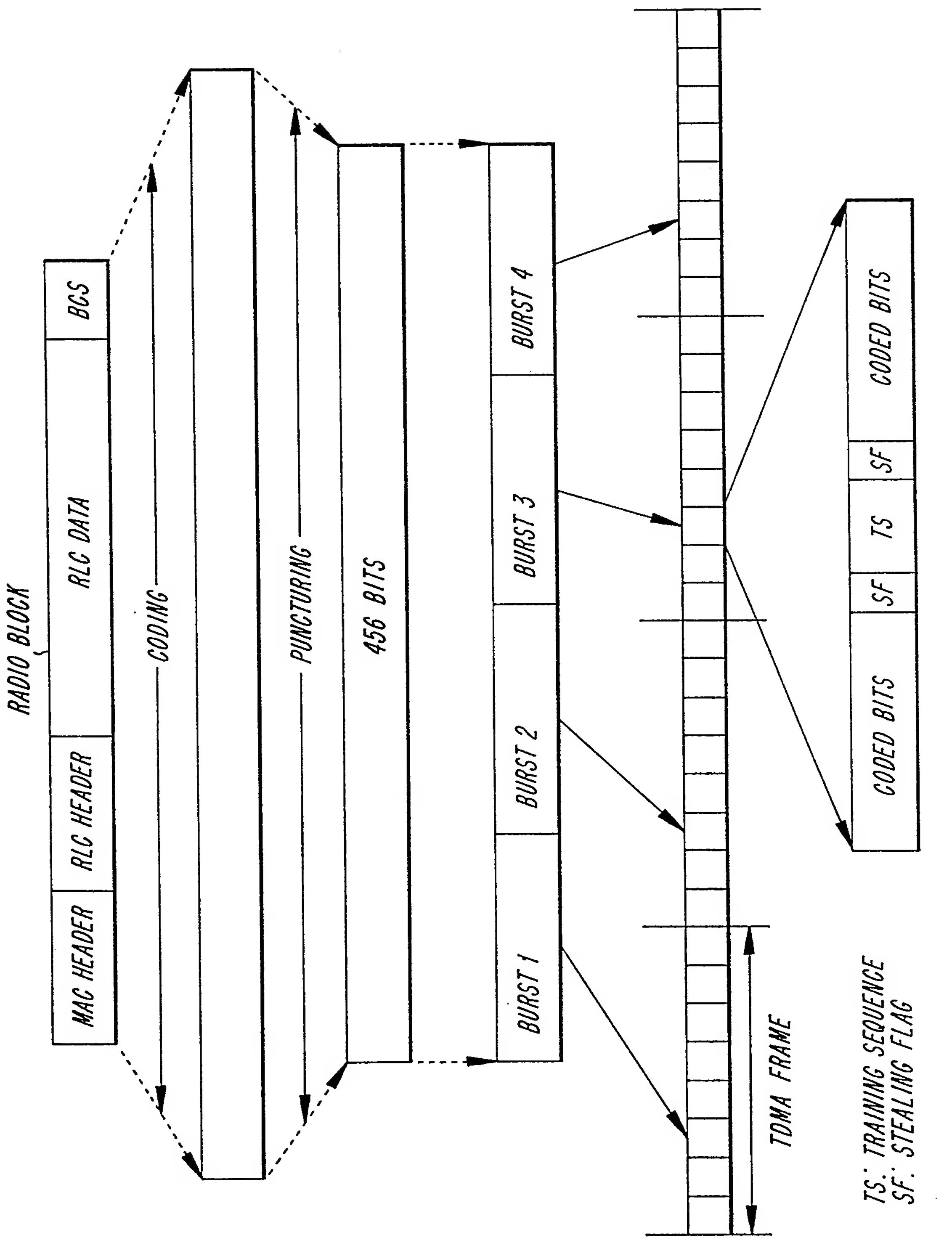

RADIO BLOCK
MAC HEADER
RLC HEADER
RLC DATA
BCS
CODING
PUNCTURING
456 BITS
BURST 1
BURST 2
BURST 3
BURST 4
TDMA FRAME
CODED BITS
SF
TS
SF
CODED BITS
TS: TRAINING SEQUENCE
SF: STEALING FLAG

Fig. 7(b)

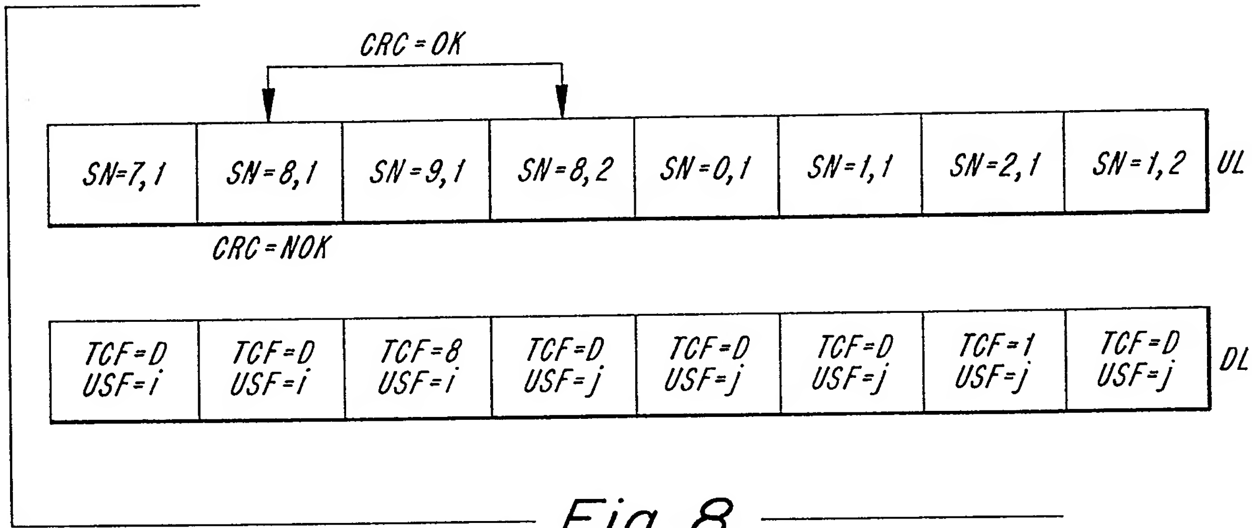

CRC = OK
SN=7,1
SN=8,1
SN=9,1
SN=8,2
SN=0,1
SN=1,1
SN=2,1
SN=1,2
UL
CRC=NOK
TCF=D USF=i
TCF=D USF=i
TCF=8 USF=i
TCF=D USF=j
TCF=D USF=j
TCF=D USF=j
TCF=1 USF=j
TCF=D USF=j
DL

Fig. 8

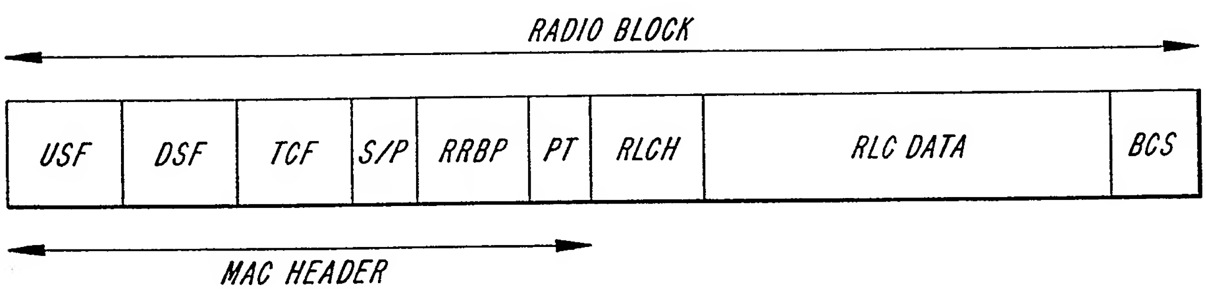
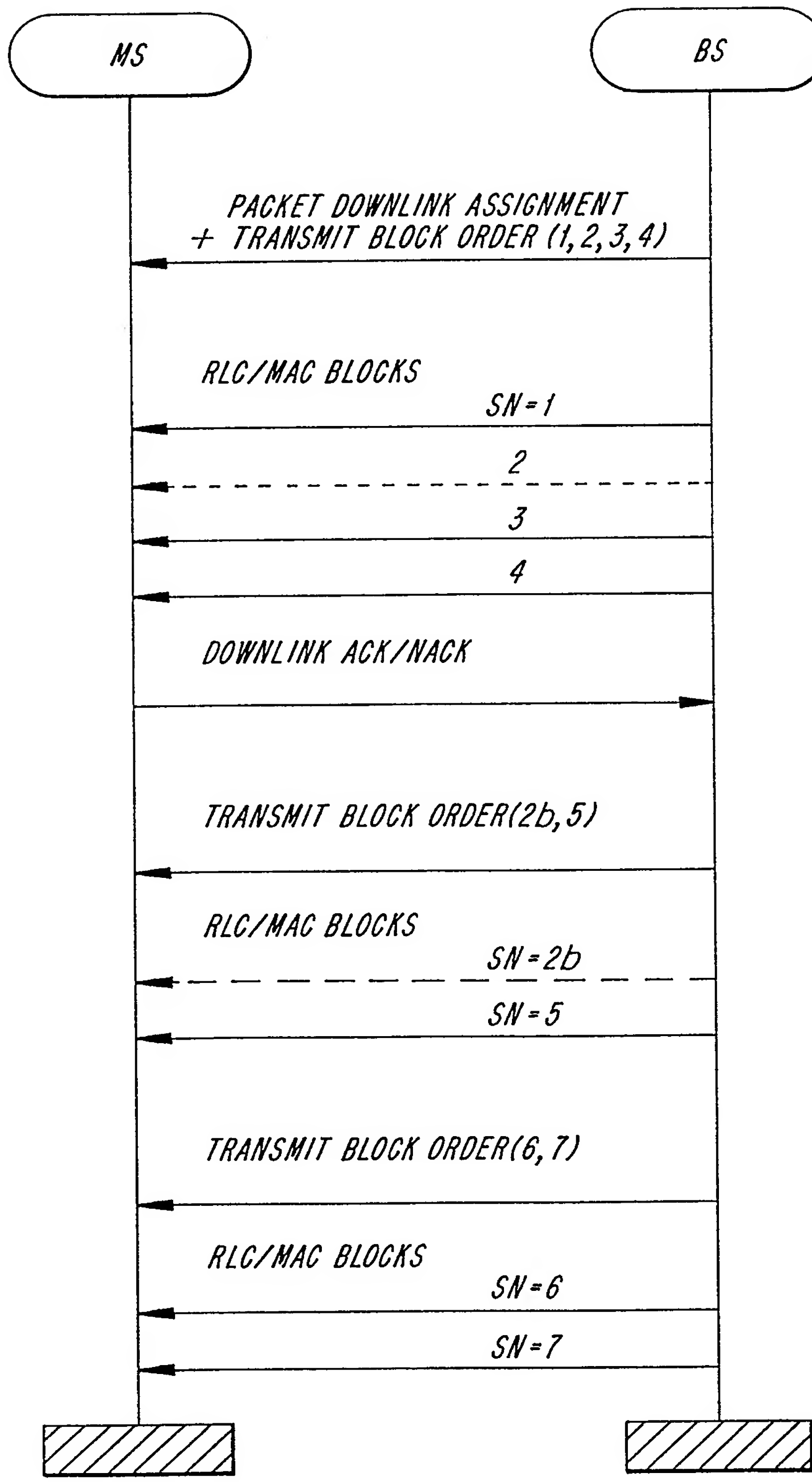

RADIO BLOCK
USF
DSF
TCF
S/P
RRBP
PT
RLCH
RLC DATA
BCS
MAC HEADER

Fig. 9

Fig. 10


MS
BS
PACKET DOWNLINK ASSIGNMENT
+ TRANSMIT BLOCK ORDER (1,2,3,4)
RLC/MAC BLOCKS
SN=1
2
3
4
DOWNLINK ACK/NACK
TRANSMIT BLOCK ORDER(2b,5)
RLC/MAC BLOCKS
SN=2b
SN=5
TRANSMIT BLOCK ORDER(6,7)
RLC/MAC BLOCKS
SN=6
SN=7

INTERNATIONAL SEARCH REPORT

Inter nal Application No
PCT/SE 99/01349

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 H04L1/18

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 H04L

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	EP 0 794 630 A (SONY CORP) 10 September 1997 (1997-09-10) abstract; claims 1-3,7,9; figures 3,4,8,9,11	1,2,10, 12,14, 15,17
Y	column 1, line 3 - line 21 column 8, line 12 - line 48 column 20, line 36 - line 47	9,19,20
A	column 22, line 50 -column 23, line 39 column 24, line 58 -column 25, line 12 ---	3-5

-/--

[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

° Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
30 November 1999	06/12/1999

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL – 2280 HV Rijswijk Tel. (+31–70) 340–2040, Tx. 31 651 epo nl, Fax: (+31–70) 340–3016	De Riccardis, F

1

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication,where appropriate, of the relevant passages	Relevant to claim No.
Y	AKYILDIZ I F ET AL: "A new ARQ protocol for wireless ATM networks" ICC '98. 1998 IEEE INTERNATIONAL CONFERENCE ON COMMUNICATIONS. CONFERENCE RECORD. AFFILIATED WITH SUPERCOMM'98 (CAT. NO.98CH36220), ATLANTA, GA, USA, 7-11 JUNE 1998, pages 1109-1113 vol.2, XP002091780 ISBN 0-7803-4788-9, 1998, New York, NY, USA, IEEE, USA	9,19,20
A	abstract; figure 1	1-3,10, 14,15
	page 1109, left-hand column, line 44 -right-hand column, line 12 page 1109, right-hand column, line 21 -page 1110, left-hand column, line 21 page 1110, right-hand column, line 16 - line 37 ---	
A	EP 0 707 394 A (NIPPON TELEGRAPH & TELEPHONE) 17 April 1996 (1996-04-17) abstract; claim 1; figure 7 column 1, line 14 - line 57 -----	1-5,10, 12,14,15

1

INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No
PCT/SE 99/01349

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
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		AU 709417 B	26-08-1999
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		CN 1168583 A	24-12-1997
		US 5889790 A	30-03-1999
EP 0707394 A	17-04-1996	CN 1128920 A	14-08-1996
		JP 2861895 B	24-02-1999
		JP 8213973 A	20-08-1996
		US 5715257 A	03-02-1998